Strength of Acids and Bases
pH and pOH

We have discussed the concentration of solutions which can be applied to acids, bases, salts, and any other solution. It's simply the number of moles of solute per liters of solution. Now we will discuss the strength of acids and bases.

According to the Arrhenius definition of acids and bases, acids are $[H^+]$ donors and bases are $[OH^-]$ donors. The concentration of $[H^+]$ and $[OH^-]$ in aqueous solutions are often numbers that are far too small to work with. In 1909, Soren Sorensen (a Danish Biochemist) proposed the pH scale of measuring the concentration of acids. The **pH** of a solution is defined as the *negative logarithm of the hydrogen ion concentration (in mol/L)*, *or in other words the negative logarithm of the molarity!!*

$pH = -\log [H_3O^+]$
$pH = -\log [H^+]$

Now, pH provides a simply way to express hydrogen ion concentrations of acidic and basic solutions at 25°C. The pH values are spread in the following manner:

Acidic Solutions: $[H^+] > 1.0 \times 10^{-7}$ M, pH < 7.00 → 0.00
Basic Solutions: $[H^+] < 1.0 \times 10^{-7}$ M, pH > 7.00 → 14.00
Neutral Solutions: $[H^+] = 1.0 \times 10^{-7}$ M, pH = 7.00

Notice that pH increases as $[H^+]$ decreases. A pH greater than 7.00 is a basic solution. A pH less than 7.00 is an acidic solution. A neutral solution will have a pH of 7.00.

- Since pH 7 is neutral
  - pH 5 is 10 x more acidic than pH 6
  - pH 4 is 100 x more acidic than pH 6
  - pH 9 is 10 x more alkaline (basic) than pH 8
  - pH 10 is 100 x more alkaline (basic) than pH 8

What about pOH?
A solution can also have a pOH reading, which is the opposite of pH and gives a reading of the concentration of $[OH^-]$ in solution. pOH is the opposite of pH.

Acidic Solutions: $[OH^-] < 1.0 \times 10^{-7}$ M, pOH > 7.00→ 14.00
Basic Solutions: $[OH^-] > 1.0 \times 10^{-7}$ M, pOH < 7.00→ 0.00
Neutral Solutions: $[OH^-] = 1.0 \times 10^{-7}$ M, pH = 7.00

$pOH = -\log [OH^-]$ If pH goes down, pOH goes up.
pH + pOH = 14.0 [(14 – pH = pOH) and (14 – pOH = pH)]

Therefore if you have a solution of 0.005 M NH_3, the solution will have a pOH as follows: pOH = -log (0.005M) = 2.3 pOH. To find the pH of the solution, you would need to do the following:
14 – 2.3 pOH = 11.7 pH

The following question may arise: "Why is the pH of 12 Molar HCl 0 and not -1.07?"

No chemical can have a pH less than 0 in an aqeous (dissolved in water) solution, but if that is the case, then how can a 12M aqueous solutoin of HCl exist if the mathematically determined pH is -1.08?

The explanation:
pH is not determined mathematically; it is determined by a pH meter. Chemistry is an experimental science, in spite of the best efforts of the theoreticians!

pH measures the ability of a solution to transfer protons, or, more formally, the ***activity*** of H^+. pH is the negative logarithm of the *activity* of H^+, which is not formally the same as the *concentration*.

At relatively low concentrations of acid, the activity of H^+ is about equal to the concentration. But by the time you reach 12 moles per liter, the concentration is no longer low and the approximation that $a_{H+} = [H^+]$ no longer holds.

The reason aqueous solutions can't have a pH lower than zero is that, at that point, the limiting factor is no longer the availability of protons but the rate at which they can be transferred from "hydronium ion," the active acid in any aqueous solution.

Concentration of hydrogen ions compared to distilled water		Examples of solutions at this pH
10,000,000	pH = 0	battery acid, strong hydrofluoric acid
1,000,000	pH = 1	hydrochloric acid secreted by stomach lining
100,000	pH = 2	lemon juice, gastric acid, vinegar
10,000	pH = 3	grapefruit, orange juice, soda
1,000	pH = 4	tomato juice, acid rain
100	pH = 5	soft drinking water, black coffee
10	pH = 6	urine, saliva
1	pH = 7	"pure" water
1/10	pH = 8	sea water
1/100	pH = 9	baking soda
1/1,000	pH = 10	Great Salt Lake, milk of magnesia
1/10,000	pH = 11	ammonia solution
1/100,000	pH = 12	soapy water
1/1,000,000	pH = 13	bleaches, oven cleaner
1/10,000,000	pH = 14	liquid drain cleaner

The scale is courtesy of The Pacific Institute for the Mathematical Sciences